PZ253E

P-611 Positioning Systems

User Manual

Version: 1.0.0 Date: 24.07.2014

This document describes the following products:

- **P-611.1**
  Linear Piezo Positioning System
  P-611.1S/.10

- **P-611.XZ / P-611.2**
  XZ and XY Nanopositioner
  P-611.2S/.20/.XZS/.XZ0

- **P-611.3**
  NanoCube® XYZ Piezo Stage
  P-611.3S/.3SF/.3O/.3OF

- **P-611.Z**
  Piezo Z Stage
  P-611.ZS/.Z0

.1S/.10/.2S/.20/.XZS/.XZ0/.ZS/.Z0
= with LEMO connector(s)

.3S/.3SF/.3O/.3OF
= with Sub-D connector

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The products described in this document are in part protected by the following patents:

German patent no. 10021919C2

German patent no. 10234787C1

German patent no. 10348836B3

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Japanese patent no. 4667863

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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download (p. 3) on our website.

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1 About this Document

In this Chapter

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Symbols and Typographic Conventions 1
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1.1 Goal and Target Audience of this User Manual

This user manual contains the necessary information for the intended use of the P-611 (x stands for the different models, see p. 9).

Basic knowledge of control technology, drive technologies and suitable safety measures is assumed.

The latest versions of the user manuals are available for download (p. 3) on our website.

1.2 Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

CAUTION

Dangerous situation

If not avoided, the dangerous situation will result in minor injury.

➢ Actions to take to avoid the situation.

NOTICE

Dangerous situation

If not avoided, the dangerous situation will result in damage to the equipment.

➢ Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/ Label	Meaning
1. 2.	Action consisting of several steps whose sequential order must be observed
➢	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5
RS-232	Labeling of an operating element on the product (example: socket of the RS-232 interface)
	Warning signs affixed to the product that refer to detailed information in this manual.

1.3 Figures

For better understandability, the colors, proportions and degree of detail in illustrations can deviate from the actual circumstances. Photographic illustrations may also differ and must not be seen as guaranteed properties.

1.4 Other Applicable Documents

The devices and software tools which are mentioned in this documentation are described in their own manuals.

The latest versions of the user manuals are available for download (p. 3) on our website.

Device	Document
E-501 modular piezo controller	PZ62E User Manual
E-503 piezo amplifier module	PZ62E User Manual
E-509 sensor / servo controller module	PZ77E User Manual
E-515 display module	PZ62E User Manual
E-517 interface and display module	PZ214E User Manual
E-564 piezo controller	Technical Note E564T0001
E-610 piezo amplifier / servo controller	PZ70E User Manual
E-621 servo controller module	PZ115E User Manual
E-625 piezo servo controller	PZ166E User Manual
E-660 piezo amplifier	PZ45E User Manual
E-663 piezo amplifier	PZ69E User Manual
E-664 NanoCube® piezo controller	PZ99E User Manual
E-665 servo controller	PZ127E User Manual
PIMikroMove	SM148E Software Manual
P-5xx / P-6xx / P-7xx piezo positioning systems	PZ240EK Short Instructions

1.5 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 37).

INFORMATION

For some products (e.g. Hexapod systems and electronics that are delivered with a CD), access to the manuals is password-protected. The password is stored on the CD. Availability of the manuals:

- Password-protected manuals: FTP download directory
- Freely available manuals: PI website

➢ Follow the corresponding instructions for downloading.

Download freely accessible manuals

1. Open the website **http://www.pi-portal.ws**.
2. Click ***Downloads***.
3. Click the corresponding product category.
4. Go to the corresponding product code.

   The available manuals are displayed.
5. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

Download password-protected manuals

1. Insert the product CD in the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including ***releasenews*** in the file name).
4. Find the user name and the password in the section "User login for software download" in the Release News.
5. Open the FTP download directory (ftp://pi-ftp.ws).
   - Windows operating systems: Open the FTP download directory in Windows Explorer.
6. Log in with the user name and the password from the Release News.
7. In the directory of the corresponding product, go to the Manuals sub-directory.
8. Copy the desired manual to the hard disk of your PC or to a data storage medium.

2 Safety

In this Chapter

Intended Use 5
General Safety Instructions 6
Organizational Measures..... 8

2.1 Intended Use

The P-611 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil, and lubricants.

Based on its design and realization, the P-611 is intended for fine positioning as well as the fast and precise motion of small objects. The specifications of the P-611 apply to horizontal mounting. The motion is performed as follows depending on the model:

Model	Motion	Axis
.1S/.10	in one axis horizontally	X
.2S/.20	in two axes horizontally	X, Y
.XZS/.XZ0	in one axis horizontally and in one axis vertically	X, Z
.3S/.3SF/.3O/.3OF	in two axes horizontally and in one axis vertically	X, Y, Z
.ZS/.Z0	in one axis vertically	Z

Vertical mounting is only possible under certain conditions.

The intended use of the P-611 is only possible in combination with suitable electronics (p. 14) that is available from PI. The electronics is not included in the scope of delivery of the P-611.

The electronics must provide the required operating voltages. To ensure proper performance of the servo-control system, the electronics must also be able to read out and process the signals from the position sensors.

2.2 General Safety Instructions

The P-611 is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the P-611.

- Only use the P-611 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the P-611.

The P-611 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After being disconnected from the electronics, piezo actuators can also stay charged for several hours. Touching or short-circuiting the contacts in the connector of the P-611 can lead to minor injuries. In addition, the piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-611.
- Discharge the piezo actuators of the stage before installation:
  Connect the stage to the switched-off PI controller, which is equipped with an internal discharge resistor.
- Do **not** pull out the connector from the electronics during operation.

For stages with Sub-D connector:

Touching the contacts in the connector can lead to an electric shock (max. 130 V DC) and minor injuries.

- Do **not** touch the contacts in the connector.
- Secure the connector of the stage with screws against being pulled out of the controller.

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-611 in the case of malfunction or failure of the system. If touch voltages exist, touching the P-611 can result in minor injuries from electric shock.

- Connect the P-611 to a protective earth conductor (p. 21) before start-up.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e. g. in the case of modifications), reconnect the P-611 to the protective earth conductor before starting it up again.

Mechanical forces can damage or misalign the P-611.

- Avoid impacts that affect the P-611.
- Do **not** drop the P-611.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 39).
- Only hold the P-611 by the holding surfaces of the base body (p. 17).

The P-611 is maintenance-free and achieves its positioning accuracy as a result of the optimum alignment of mechanical components and piezo actuators. Loosened screws cause a loss in positioning accuracy.

- Only loosen screws according to the instructions in this manual.
- Do **not** open the P-611.

2.3 Organizational Measures

User manual

- Always keep this user manual available by the P-611.
  The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- If you pass the P-611 on to other users, also turn over this user manual as well as other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in minor injury and property damage.
- Only install and operate the P-611 after having read and understood this user manual.

Personnel qualification

The P-611 may only be installed, started up, operated, maintained and cleaned by authorized and appropriately qualified personnel.

3 Product Description

In this Chapter

Model Overview 9
Product View 10
Product Labeling 12
Scope of Delivery 14
Suitable Electronics 14
Technical Features 15

3.1 Model Overview

The following standard versions of the P-611 are available:

P-611.1: Linear Piezo Positioning System

Model	Description
P-611.1S	Linear nanopositioning system, 100 µm, strain gauge sensor
P-611.10	Linear nanopositioning system, 120 µm, open-loop

P-611.XZ / P-611.2: XZ and XY Nanopositioner

Model	Description
P-611.2S	XY nanopositioning system, 100 µm × 100 µm, strain gauge sensors
P-611.20	XY nanopositioning system, 100 µm × 100 µm, open-loop
P-611.XZS	XZ nanopositioning system, 100 µm × 100 µm, strain gauge sensors
P-611.XZ0	XZ nanopositioning system, 100 µm × 100 µm, open-loop

P-611.3: NanoCube® XYZ Piezo Stage

Model	Description
P-611.3S	NanoCube® XYZ nanopositioning system, 100 µm × 100 µm × 100 µm, strain gauge sensors

Model	Description
P-611.3SF	NanoCube® XYZ nanopositioning system, 100 µm × 100 µm × 100 µm, strain gauge sensors, integrated fiber holder
P-611.3O	NanoCube® XYZ nanopositioning system, 100 µm × 100 µm × 100 µm, open-loop
P-611.3OF	NanoCube® XYZ nanopositioning system, 100 µm × 100 µm × 100 µm, open-loop, integrated fiber holder

P-611.Z: Piezo Z Stage

Model	Description
P-611.ZS	Vertical nanopositioning stage, 100 µm, strain gauge sensor
P-611.Z0	Vertical nanopositioning stage, 110 µm, open-loop

3.2 Product View

The figures serve as examples and can differ from your stage model.

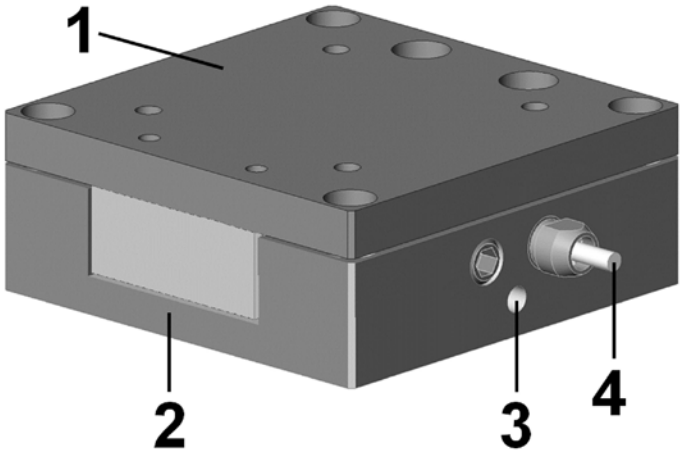
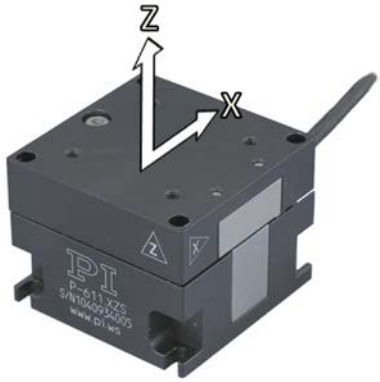
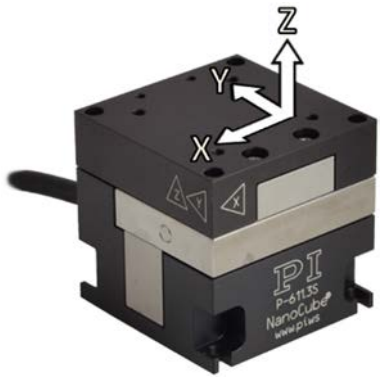


Figure 1: Example of product view

1 Moving platform
2 Base body
3 Protective earth connection
4 Cable exit

Directions of motion of the P-611

The arrows each represent the positive direction of motion.

<table>
<tr>
<td>P-611.1x
 </td>
<td>P-611.Zx
 </td>
</tr>
<tr>
<td>P-611.2x
 </td>
<td>P-611.XZx
  </td>
</tr>
<tr>
<td>P-611.3x / P-611.3xF
  </td>
<td></td>
</tr>
</table>

3.3 Product Labeling

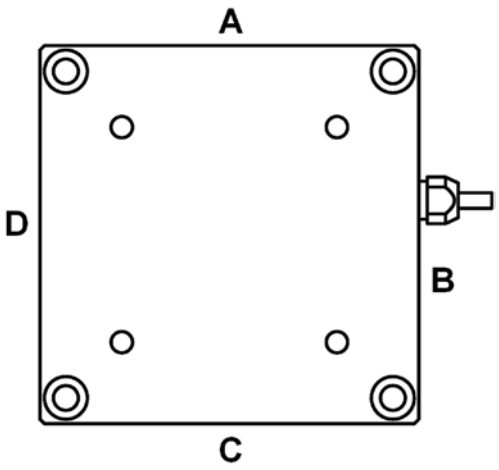


Figure 2: P-611: Position of the product labeling (example of a view from above)

Labeling	Description	Model-Dependent Position	
		Model	Position
Triangular arrow with the letter X	Positive direction of motion of the X axis	.1x / .XZx	C
		.2x	B
		.3x / .3xF	D
Triangular arrow with the letter Y	Positive direction of motion of the Y axis	.2x	C
		.3x / .3xF	A
Triangular arrow with the letter Z	Positive direction of motion of the Z axis	.Zx	C
		.XZx	D
		.3x / .3xF	A
NanoCube®	Brand name	.3x / .3xF	D
PI	Manufacturer's logo	.2Sx	A
		Other models	D
WWW.PI.WS	Manufacturer's address (website)	.2Sx	A
		Other models	D
P-611.XZS	Product name (example), the places after the point refer to the model	.2Sx	A
		Other models	D

Labeling	Description	Model-Dependent Position	
		Model	Position
114031266	Serial number (example), individual for each P-611 Meaning of the places (counting from left): 1 = internal information 2 and 3 = manufacturing year 4 to 9 = consecutive numbers	.2Sx:	A
		Other models	D
Country of origin: Germany	Country of origin	.2Sx	A
		Other models	D
⚠	Warning sign "Observe manual!"	.2Sx	A
		Other models	D
	Old equipment disposal (p. 55)	.2Sx	A
		Other models	D
CE	CE conformity mark	.2Sx	A
		Other models	D
⏚	Symbol for the protective earth conductor, marks the protective earth connection of the P-611	.2Sx	A
		Other models	B

Figure 3: P-611: "Residual voltage" warning sign on connector

Warning sign "Residual voltage": Notice of risk of electric shock (p. 6)

3.4 Scope of Delivery

Order Number	Components
P-611	Stage according to order (p. 9)
000036450	M4 screw set for protective earth, consisting of: ▪ 1 M4x8 flat-head screw with cross recess, ISO 7045 ▪ 2 safety washers ▪ 2 flat washers
PZ240EK	Short instructions for piezo positioning systems

3.5 Suitable Electronics

To operate a P-611, you need suitable electronics. Devices are selected depending on the type of application. The following table lists suitable devices (x = suitable).

Electronics	Channels	P-611 Model					
		.1S .ZS	.10 .Z0	.2S .XZS	.20 .XZ0	.3S .3SF	.3O .3OF
E-610 piezo amplifier / servo controller, OEM module	1	x	x	x*	x*	x*	x*
E-625 piezo servo controller (bench-top)	1	x	x	x*		x*	
E-665 servo controller (bench-top)	1	x					
E-621 servo controller module	1	x		x*		x*	
E-660 piezo amplifier (bench-top)	1		x				
E-501 modular piezo controller, consisting of: ▪ E-503 piezo amplifier module ▪ Only models with sensor: E-509.S3N sensor / servo controller module Optional: E-517 interface and display module or E-515 display module	3			x	x	x	x

Electronics	Channels	P-611 Model					
		.1S .ZS	.10 .Z0	.2S .XZS	.20 .XZ0	.3S .3SF	.3O .3OF
E-564 3-channel piezo controller with digital interface	3			x	x	x	x
E-664 NanoCube® piezo controller	3					x	
E-663 piezo amplifier (bench-top)	3						x

* One device per axis

3.6 Technical Features

3.6.1 PICMA® Piezo Actuators

P-611 stages are driven by PICMA® piezo actuators. PICMA® actuators have all-ceramic insulation and are therefore far superior to conventional actuators in respect to performance and lifetime. The monolithic piezoceramic block is protected against humidity and failure due to increased leakage current by a ceramic insulation layer. In this way, an especially high reliability is achieved even under extreme ambient conditions. In contrast to motorized drives, there are no rotating parts or friction. The piezo actuators are therefore backlash-, maintenance- and wear-free.

3.6.2 Flexure Guides

P-611 stages have flexure guides (flexures) for frictionless motion and high guiding accuracies.

A flexure guide is an element which is free from static and sliding friction. It is based on the elastic deformation (bending) of a solid (e.g. steel) and does not have any rolling or sliding parts. Flexure elements have a high stiffness and load capacity. Flexure guides are maintenance- and wear-free. They are 100 % vacuum compatible, function in a wide temperature range and do not require any lubricants.

3.6.3 Strain Gauge Sensors (SGS)

Strain gauge sensors derive the position information from their expansion. They are attached at a suitable position in the drivetrain, where they measure the displacement of the moving stage part against the base body. This type of position measurement is done with contact and indirectly, since the position of the moving platform is derived from a measurement on the lever, guide or piezo stack.

The sensors are equipped with a full-bridge circuit that is insensitive to thermal drift, and assure optimum position stability in the nanometer range.

4 Unpacking

NOTICE

Mechanical overload from incorrect handling!

Impermissible mechanical loading of the moving platform as well as certain surfaces of the P-611 can lead to damage to the piezo actuators, sensors and flexure joints of the P-611 as well as to loss of accuracy. In addition, the P-611 can be damaged from tensile forces on the cable exit and bending of the connection cable.

- ➢ Only hold the P-611 by the holding surfaces of the base body (p. 17).
- ➢ Avoid tensile forces on the cable exit and do not bend the cable.

The figure serves as an example and can differ from your stage model.

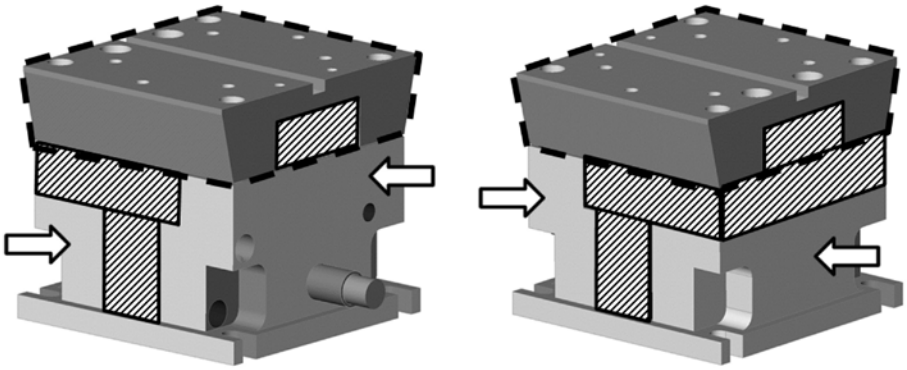


Figure 4: P-611: Holding surfaces to be used on the base body (see arrows)

Areas to be protected against the application of forces:
- Moving platform (framed with a dashed line)
- Non-anodized surfaces (hatched)

1. Unpack the P-611 carefully:
   a) Spread the foam packaging apart with one hand.
   b) Grasp the stage by the holding surfaces.
   c) Grasp all connection cables of the stage with your other hand.
   d) Carefully remove the stage and the connection cables from the foam packaging at the same time.

2. Compare the contents against the items covered by the contract and against the packing list.
3. Inspect the contents for signs of damage. If there is any sign of damage or missing parts, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

In this Chapter

General Notes on Installation 19
Connecting the P-611 to the Protective Earth Conductor 21
Mounting the P-611 23
Affixing the Load 25

5.1 General Notes on Installation

CAUTION

Dangerous voltage and residual charge on piezo actuators!

The P-611 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After being disconnected from the electronics, piezo actuators can also stay charged for several hours. Touching or short-circuiting the contacts in the connector of the P-611 can lead to minor injuries. In addition, the piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-611.
- Discharge the piezo actuators of the stage before installation:
  Connect the stage to the switched-off PI controller, which is equipped with an internal discharge resistor.
- Do **not** pull out the connector from the electronics during operation.

For stages with Sub-D connector:

Touching the contacts in the connector can lead to an electric shock (max. 130 V DC) and minor injuries.

- Do **not** touch the contacts in the connector.
- Secure the connector of the stage with screws against being pulled out of the controller.

NOTICE

Mechanical overload from incorrect handling!

Impermissible mechanical loading of the moving platform as well as certain surfaces of the P-611 can lead to damage to the piezo actuators, sensors and flexure joints of the P-611 as well as to loss of accuracy. In addition, the P-611 can be damaged from tensile forces on the cable exit and bending of the connection cable.

- ➢ Only hold the P-611 by the holding surfaces of the base body (p. 17).
- ➢ Avoid tensile forces on the cable exit and do not bend the cable.

NOTICE

Damage from unsuitable cables!

Unsuitable cables can damage the stage and the electronics.

- ➢ Only use cables provided by PI for connecting the P-611 to the electronics.

NOTICE

Damage from incorrect mounting!

Incorrect mounting of the P-611 or incorrectly mounted parts can damage the P-611.

- ➢ Only mount the P-611 and the loads on the mounting fixtures (holes) intended for this purpose.

NOTICE

Damage due to incorrectly tightened screws!

Incorrectly tightened screws can cause damage.

- ➢ Observe the torque range (p. 52) given for the screws used during installation.

INFORMATION

Extended cables can reduce the positioning accuracy of the P-611 or affect the sensor processing by the electronics.

- ➢ Do **not** use cable extensions. If you need longer cables, contact our customer service department (p. 37).

5.2 Connecting the P-611 to the Protective Earth Conductor

INFORMATION

In the case of P-611 stages with Sub-D connectors, ground loops can occur when the stage is grounded via its protective earth connector as well as by the shield of the connection cable for the electronics.

➢ If a ground loop occurs, contact our customer service department (p. 37).

INFORMATION

➢ Observe the applicable standards for mounting the protective earth conductor.

The P-611 has an M4 hole for mounting the protective earth conductor. This hole is marked with the symbol for the protective earth conductor ⏚. For the precise position of the hole, see "Dimensions" (p. 45).

Prerequisite

✓ You have read and understood the general notes on installation (p. 19).

✓ The stage is **not** connected to the electronics.

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable ≥0.75 mm^2
- Supplied M4 protective earth screw set (p. 14) for connecting the protective earth conductor
- Suitable screwdriver

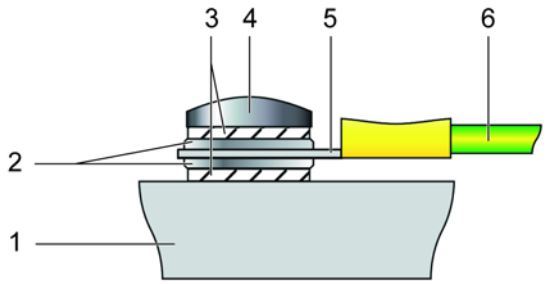


Figure 5: Mounting of the protective earth conductor (profile view)

1 Base body of the P-611
2 Flat washer
3 Safety washer
4 Screw
5 Cable lug
6 Protective earth conductor

Connecting the P-611 to the protective earth conductor

1. If necessary, fasten a suitable cable lug to the protective earth conductor.
2. Fasten the cable lug of the protective earth conductor using the M4 screw on the protective earth connection of the P-611 as shown in the profile view.
3. Tighten the M4 screw with a torque of 1.2 Nm to 1.5 Nm.
4. Make sure that the contact resistance at all connection points relevant for mounting the protective earth conductor is <0.1 Ω at 25 A.

5.3 Mounting the P-611

NOTICE

Warping of the P-611 due to mounting on uneven surfaces!

Mounting the P-611 on an uneven surface can warp the P-611. Warping reduces the accuracy.

- ➢ Mount the P-611 on an even surface. The recommended evenness of the surface is ≤20 µm.
- ➢ For applications with great temperature changes:
  Only mount the P-611 on surfaces that have the same or similar thermal expansion properties as the P-611.

NOTICE

Tensile stress on piezo actuator with vertical mounting!

When the stage is mounted vertically, tensile stress can result in particular alignments that reduces the preload of the piezo actuator and thus destroys it.

- ➢ If you want to mount the P-611 vertically, contact our customer service department (p. 37).

NOTICE

Protruding screw heads!

Protruding screw heads can damage the P-611.

- ➢ Ensure that the screw heads do not protrude from counter-sunk holes so that they do not interfere with the stage motion.

The following figures serve as examples and can differ from your stage model.

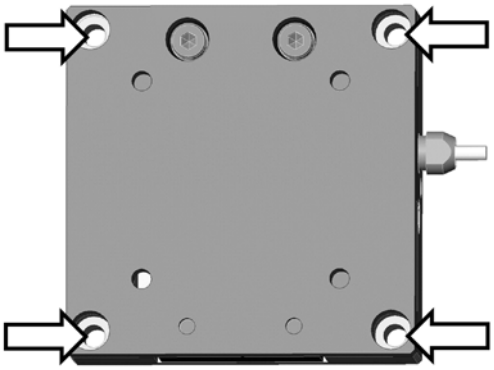


Figure 6: P-611.1x and .2x: Holes for mounting the stage on a surface

Number of mounting holes:
P-611.1x: 4
P-611.2x: 3

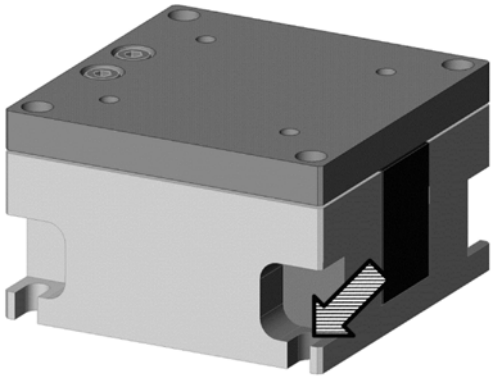


Figure 7: P-611.XZx, .3x, .3xF and .Zx: One of four recesses in the base body

Prerequisite

✓ You have read and understood the general notes on installation (p. 19).

Tools and accessories

- When mounting a P-611.2x:
  - 3 screws of suitable size and length (p. 45)
- When mounting other models of the P-611:
  - 4 screws of suitable size and length (p. 45)
- Suitable screwdriver

Mounting the stage on a surface

1. Position the stage on an even surface.
2. Introduce the screws:

   When mounting a P-611.1x or .2x:

   – Introduce the screws into the counter-sunk holes in the base body of the P-611 from above.

   When mounting a P-611.XZx, .3x, .3xF or .Zx:

   – Introduce the screws into the recesses in the base body of the P-611 from the side.
3. Tighten the screws. Observe the specified torque range (p. 52) while doing so.

5.4 Affixing the Load

NOTICE

Mechanical overload due to high torques and high loads!

When affixing the load, high torques and high loads can overload the moving platform of the P-611. Mechanical overload can cause damage to the piezo actuators, sensors and flexure joints of the P-611 and lead to losses in accuracy.

- ➢ Observe the torque range (p. 52) given for the screws used during installation.
- ➢ Avoid torques >50Ncm on the moving platform.
- ➢ Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 39).

NOTICE

Warping of the P-611 due to affixing of loads with uneven contact surface!

Affixing loads with an uneven contact surface can warp the P-611. Warping reduces the accuracy.

- ➢ Only affix loads on the P-611 whose contact surface with the moving platform of the stage has an evenness of at least 20 µm.
- ➢ For applications with great temperature changes:
  Only affix loads on the P-611 that have the same or similar thermal expansion properties as the P-611.

NOTICE

Center of load at unsuitable position!

If the center of load is located far outside of the moving platform (e. g. high set-ups and long levers), the P-611 can be damaged from high strain on the flexure guides, high torques and oscillations.

- ➢ If the center of the load to be affixed is far above or to the side of the moving platform, adjust the controller settings before start-up or contact our customer service department (p. 37).

NOTICE

Screws that are too long!

The P-611 can be damaged by screws that are too long.

- ➢ Note the depth of the mounting holes in the moving platform (p. 45).
- ➢ Only use screws of the correct length for the respective mounting holes.

INFORMATION

The positive direction of motion of the axes is given in the product view (p. 10).

Center of load at the optimum position:

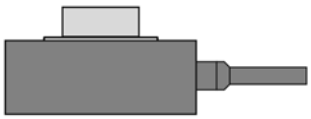


Figure 8: Example of an optimally affixed load

Center of load at an unsuitable position:

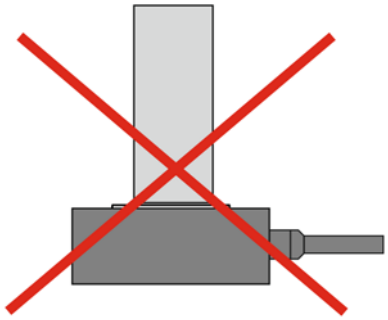


Figure 9: High set-up and center of load far above the moving platform

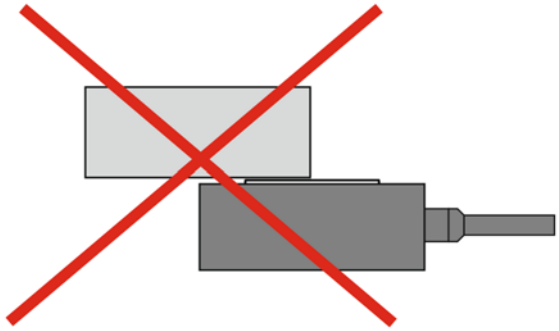


Figure 10: Long lever and center of load on the side of the moving platform

Prerequisite

✓ You have read and understood the general notes on installation (p. 19).

Tools and accessories

- Screws of appropriate size and length (p. 45)
- Suitable tools

Affixing the load

➢ Only affix loads to the threaded holes (p. 45) intended for this purpose and with suitable screws. Observe the specified torque range (p. 52) while doing so.

➢ Affix the load so that it is centered and that the center of load is on the moving platform.

6 Start-Up and Operation

In this Chapter

General Notes on Start-Up and Operation 29
Operating the P-611 31
Discharging the P-611 31

6.1 General Notes on Start-Up and Operation

CAUTION

Risk of electric shock if the protective earth conductor is not connected!

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-611 in the case of malfunction or failure of the system. If touch voltages exist, touching the P-611 can result in minor injuries from electric shock.

- ➢ Connect the P-611 to a protective earth conductor (p. 21) before start-up.
- ➢ Do **not** remove the protective earth conductor during operation.
- ➢ If the protective earth conductor has to be removed temporarily (e. g. in the case of modifications), reconnect the P-611 to the protective earth conductor before starting it up again.

NOTICE

Destruction of the piezo actuator by electric flashovers!

The use of the P-611 in environments that increase the electrical conductivity can lead to the destruction of the piezo actuator by electric flashovers. Electric flashovers can be caused by moisture, high humidity, liquids and conductive materials such as metal dust. In addition, electric flashovers can also occur in certain air pressure ranges due to the increased conductivity of the air.

- ➢ Avoid operating the P-611 in environments that can increase the electric conductivity.
- ➢ Only operate the P-611 within the permissible ambient conditions and classifications (p. 44).

NOTICE

Reduced lifetime of the piezo actuator due to permanently high voltage!

The permanent application of a high static voltage to piezo actuators leads to a considerable reduction in the lifetime of the piezo ceramics of the actuator.

- ➢ When the P-611 is not used but the controller remains switched on to ensure temperature stability, discharge the P-611 (p. 31).

NOTICE

Operating voltage too high or incorrectly connected!

Operating voltages that are too high or incorrectly connected can cause damage to the P-611.

- ➢ Only operate the P-611 with controllers/drivers and original accessories from PI.
- ➢ Do **not** exceed the operating voltage range (p. 43) for which the P-611 is specified.
- ➢ Only operate the P-611 when the operating voltage is properly connected; see "Pin Assignment" (p. 52).

NOTICE

Uncontrolled oscillation!

Oscillations can cause irreparable damage to the stage. Oscillations are indicated by a humming and can result from the following causes:

- A change in the load and/or dynamics requires the servo-control parameters to be adjusted.
- The stage is operated near its resonant frequency.

If you notice oscillations:

- ➢ In closed-loop operation, immediately switch off the servo mode.
- ➢ In open-loop operation, immediately stop the stage.

INFORMATION

The positive direction of motion of the axes is given in the product view (p. 10).

INFORMATION

Sound and vibration (e.g. footfall, impacts) can be transmitted to the stage and can affect its performance with regard to position stability.

- ➢ Avoid transmitting sound and vibration while the stage is being operated.

6.2 Operating the P-611

➢ Follow the instructions in the manual of the controller used for start-up and operation of the P-611.

6.3 Discharging the P-611

The P-611 must be discharged in the following cases:

- Before installation
- If the P-611 is not used but the controller remains switched on to ensure temperature stability
- Before demounting (e.g. before cleaning and transporting the P-611 and for modifications)

The P-611 is discharged through the internal discharge resistor of the controller from PI.

Discharging a P-611 that is connected to the controller

In closed-loop operation:

1. Switch off the servo mode on the controller.
2. Set the piezo voltage to 0 V on the controller.

In open-loop operation:

➢ Set the piezo voltage to 0 V on the controller.

Discharging a P-611 that is not connected to the controller

➢ Connect the stage to the switched-off controller from PI.

7 Maintenance

In this Chapter

General Notes on Maintenance 33
Cleaning the P-611 33

7.1 General Notes on Maintenance

NOTICE

Misalignment from loosening screws!

The P-611 is maintenance-free and achieves its positioning accuracy as a result of the optimum alignment of mechanical components and piezo actuators. Loosened screws cause a loss in positioning accuracy.

- ➢ Only loosen screws according to the instructions in this manual.
- ➢ Do **not** open the P-611.

7.2 Cleaning the P-611

Prerequisites

- ✓ You have discharged the piezo actuators of the P-611 (p. 31).
- ✓ You have disconnected the P-611 from the controller.

Cleaning the P-611

- ➢ Clean the surfaces of the P-611 with a cloth that is slightly dampened with a mild cleanser or disinfectant (e.g. ethanol or isopropanol).
- ➢ Do **not** do any ultrasonic cleaning.

8 Troubleshooting

Problem	Possible Causes	Solution
No or limited motion	The cable is not connected correctly	➢ Check the cable connections.
	Excessive load	➢ Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 39).
	Zero shift of the sensor for the following reasons: ▪ Load applied in direction of motion ▪ Ambient/operating temperature of the stage far above or below calibration temperature (21°C to 24°C)	➢ Perform a zero-point adjustment of the sensor (see controller manual).
Reduced accuracy	Warping of the base body or the moving platform	➢ Only mount the P-611 on surfaces with the following characteristics: – Evenness of at least 20 µm – The thermal expansion properties are similar to those of the P-611 (e. g. surfaces made of aluminum). ➢ Only affix loads with the following characteristics on the P-611: – The contact surface of the load has an evenness of at least 20 µm. – The thermal expansion properties are similar to those of the P-611 (e. g. loads made of aluminum).

Problem	Possible Causes	Solution
	P-611 or controller has been replaced	After the P-611 or controller has been replaced, it is necessary to recalibrate the axis displacement. ➢ Perform a recalibration of the axis displacement (see controller manual) or contact our customer service department (p. 37).
	Axes were mixed up during connection (only with LEMO connectors)	➢ Observe the assignment of the axes when connecting the stage to the controller. This assignment is indicated by labels on the devices.
	The stage is not connected to the corresponding controller (only with several systems)	➢ Observe the assignment of the devices when several systems are connected. The assignment is indicated on the calibration label of the controller (see rear panel or bottom side), which contains the serial number of the stage to be connected.
The stage starts oscillating or positions inaccurately	Servo-control parameters incorrectly set because e. g. the load was changed	1. Immediately switch off the servo mode of the corresponding stage axes. 2. Check the settings of the servo-control parameters on the controller. 3. Adjust the servo-control parameters on the controller according to the load change.
	Open-loop operation near the resonant frequency	➢ In open-loop operation, only operate the stage with a frequency that is below the resonant frequency.

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 37).

9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (info@pi.ws).

If you have questions concerning your system, have the following information ready:

- Product codes and serial numbers of all products in the system
- Firmware version of the controller (if present)
- Version of the driver or the software (if present)
- Operating system on the PC (if present)

The latest versions of the user manuals are available for download (p. 3) on our website.

10 Technical Data

In this Chapter

Specifications 39
Dimensions 45
Torque for Stainless Steel Screws (A2-70) 52
Pin Assignment 52

10.1 Specifications

10.1.1 Data Table

	P-611.1S	P-611.10	Unit	Tolerance
Active axes	X	X		
Motion and positioning				
Integrated sensor	SGS	-		
Open-loop travel, -20 to +120 V	120	120	µm	min. (20 % / -0 %)
Closed-loop travel	100	-	µm	
Open-loop resolution	0.2	0.2	nm	typ.
Closed-loop resolution	2	-	nm	typ.
Linearity error, closed-loop	0.1	-	%	typ.
Repeatability	<10	-	nm	typ.
Pitch	±5	±5	µrad	typ.
Yaw	±20	±20	µrad	typ.
Flatness	10	10	nm	typ.
Mechanical properties				
Stiffness in motion direction	0.2	0.2	N/µm	±20 %
Unloaded resonant frequency	400	400	Hz	±20 %
Resonant frequency @ 30 g	300	300	Hz	±20 %
Resonant frequency @ 100 g	195	195	Hz	±20 %
Push / pull force capacity in motion direction	15 / 10	15 / 10	N	max.
Load capacity	15	15	N	max.
Drive properties				
Ceramic type	PICMA® P-885	PICMA® P-885		
Electrical capacitance	1.5	1.5	µF	±20 %
Dynamic operating current coefficient	1.9	1.9	µA/(Hz × µm)	±20 %
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	°C	
Material	Aluminum, steel	Aluminum, steel		
Dimensions	44 mm × 44 mm × 17 mm	44 mm × 44 mm × 17 mm		
Mass	0.135	0.135	kg	±5 %
Cable length	1.5	1.5	m	±10 mm
Voltage connection	LEMO	LEMO		
Sensor connection	LEMO	-		

The resolution of PI piezo nanopositioning systems is not limited by friction or stiction. Value given is noise equivalent motion with E-503 amplifier.
Dynamic operating current coefficient in µA per Hz and µm. Example: Sine operation with 50 µm at 10 Hz requires approximately 0.9 mA of current.

	P-611.2S	P-611.20	P-611.XZS	P-611.XZ0	Unit	Tolerance
Active axes	X, Y	X, Y	X, Z	X, Z		
Motion and positioning						
Integrated sensor	SGS	–	SGS	–		
Open-loop travel, -20 to 120 V	120	120	120	120	µm	min. (20 % / -0 %)
Closed-loop travel	100	–	100	–	µm	
Open-loop resolution	0.2	0.2	0.2	0.2	nm	typ.
Closed-loop resolution	2	–	2	–	nm	typ.
Linearity error	0.1	–	0.1	–	%	typ.
Repeatability	<10	–	<10	–	nm	typ.
Pitch in X, Y	±5	±5	±5	±5	µrad	typ.
Runout θ_X (motion in Z)	–	–	±10	±10	µrad	typ.
Yaw in X	±20	±20	±20	±20	µrad	typ.
Yaw in Y	±10	±10	–	–	µrad	typ.
Runout θ_Y (motion in Z)	–	–	±10	±10	µrad	typ.
Mechanical properties						
Stiffness	0.2	0.2	0.2 Z: 0.35	0.2 Z: 0.35	N/µm	±20 %
Resonant frequency, no load	X: 345; Y: 270	X: 345; Y: 270	X: 365; Z: 340	X: 365; Z: 340	Hz	±20 %
Resonant frequency, under load, at 30 g	X: 270; Y: 225	X: 270; Y: 225	X: 280; Z: 295	X: 280; Z: 295	Hz	±20 %
Resonant frequency, under load, at 100 g	X: 180; Y: 165	X: 180; Y: 165	X: 185; Z: 230	X: 185; Z: 230	Hz	±20 %
Push / pull force capacity in motion direction	15 / 10	15 / 10	15 / 10	15 / 10	N	max.
Load capacity	15	15	15	15	N	max.
Drive properties						
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885		
Electrical capacitance	1.5	1.5	1.5	1.5	µF	±20 %
Dynamic operating current coefficient	1.9	1.9	1.9	1.9	µA / (Hz × µm)	±20 %
Miscellaneous						
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C	
Material	Aluminum, steel	Aluminum, steel	Aluminum, steel	Aluminum, steel		
Dimensions	44 mm × 44 mm × 25 mm	44 mm × 44 mm × 25 mm	44 mm × 44 mm × 34 mm	44 mm × 44 mm × 34 mm		
Mass	0.235	0.235	0.27	0.27	kg	±5 %
Cable length	1.5	1.5	1.5	1.5	m	±10 mm
Sensor connection	LEMO	–	LEMO	–		
Voltage connection	LEMO	LEMO	LEMO	LEMO		

The resolution of PI piezo nanopositioning systems is not limited by friction or stiction. Value given is noise equivalent motion with E-503 amplifier.

Dynamic operating current coefficient in µA per Hz and µm. Example: Sine operation with 50 µm at 10 Hz requires approximately 0.9 mA of current.

	P-611.3S P-611.3SF	P-611.3O P-611.3OF	Unit	Tolerance
Active axes	X, Y, Z	X, Y, Z		
Motion and positioning				
Integrated sensor	SGS			
Open-loop travel, -20 to 120 V	120 / axis	120 / axis	µm	min. (20 % / -0%)
Closed-loop travel	100 / axis	–	µm	
Open-loop resolution	0.2	0.2	nm	typ.
Closed-loop resolution	1	–	nm	typ.
Linearity error	0.1	–	%	typ.
Repeatability	<10	–	nm	typ.
Pitch in X, Y	±5	±5	µrad	typ.
Runout θ_X (motion in Z)	±10	±10	µrad	typ.
Yaw in X	±20	±20	µrad	typ.
Yaw in Y	±10	±10	µrad	typ.
Runout θ_Y (motion in Z)	±10	±10	µrad	typ.
Mechanical properties				
Stiffness	0.3	0.3	N/µm	±20 %
Unloaded resonant frequency X / Y / Z	350 / 220 / 250	350 / 220 / 250	Hz	±20 %
Resonant frequency at 30 g in X / Y / Z	270 / 185 / 230	270 / 185 / 230	Hz	±20 %
Resonant frequency at 100 g in X / Y / Z	180 / 135 / 200	180 / 135 / 200	Hz	±20 %
Push / pull force capacity in motion direction	15 / -10	15 / -10	N	max.
Load capacity	15	15	N	max.
Drive properties				
Ceramic type	PICMA® P-885	PICMA® P-885		
Electrical capacitance	1.5	1.5	µF	±20 %
Dynamic operating current coefficient	1.9	1.9	µA/(Hz × µm)	±20 %
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	°C	
Material	Aluminum, steel	Aluminum, steel		
Dimensions	48 mm × 44 mm × 43.2 mm SF version: 44 mm × 50 mm × 44.2 mm	44 mm × 44 mm × 43.2 mm OF version: 44 mm × 50 mm × 44.2 mm		
Mass	0.32	0.32	kg	±5 %
Cable length	1.5	1.5	m	±10 mm
Sensor connection	Sub-D connector	–		
Voltage connection	Sub-D connector	Sub-D connector		

The resolution of PI piezo nanopositioning systems is not limited by friction or stiction. Value given is noise equivalent motion with E-503 amplifier.
Dynamic operating current coefficient in µA per Hz and µm. Example: Sine operation with 50 µm at 10 Hz requires approximately 0.9 mA of current.
Adapter cable with LEMO connectors for sensor and operating voltage available.

	P-611.ZS	P-611.Z0	Unit	Tolerance
Active axes	Z	Z		
Motion and positioning				
Integrated sensor	SGS	-		
Open-loop travel, -20 to +120 V	120	120	µm	min. (20% / -0%)
Closed-loop travel	100	-	µm	
Open-loop resolution	0.2	0.2	nm	typ.
Closed-loop resolution	2	-	nm	typ.
Linearity error	0.1	-	%	typ.
Repeatability	<10	-	nm	typ.
Runout θ_Z (Z motion)	±5	±5	µrad	typ.
Runout θ_X (Z motion)	±20	±20	µrad	typ.
Runout θ_Y (Z motion)	±5	±5	µrad	typ.
Mechanical properties				
Stiffness	0.45	0.45	N/µm	±20 %
Unloaded resonant frequency	460	460	Hz	±20 %
Resonant frequency @ 30 g	375	375	Hz	±20 %
Resonant frequency @ 100 g	265	265	Hz	±20 %
Push / pull force capacity	15 / 10	15 / 10	N	max.
Drive properties				
Ceramic type	PICMA® P-885	PICMA® P-885		
Electrical capacitance	1.5	1.5	µF	±20 %
Dynamic operating current coefficient	1.9	1.9	µA/(Hz × µm)	±20 %
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	°C	
Material	Aluminum, steel	Aluminum, steel		
Dimensions	44 mm × 44 mm × 27 mm	44 mm × 44 mm × 27 mm		
Mass	176	176	g	±5 %
Cable length	1.5	1.5	m	±10 mm
Sensor connection	LEMO	LEMO		
Voltage connection	LEMO	LEMO		

The resolution of PI piezo nanopositioning systems is not limited by friction or stiction. Value given is noise equivalent motion with E-503 amplifier.

System properties

System configuration: P-611.ZS and E-665.SR controller with 30 g load
Small signal bandwidth: 40 Hz
Settling time (10 % step width): 25 ms

10.1.2 Maximum Ratings

P-611 stages are designed for the following operating data:

Stage	Maximum Operating Voltage	Maximum Operating Frequency (Unloaded)	Maximum Power Consumption
P-611.1S P-611.10	-20 to +120 V	133 Hz	3.9 W
P-611.2S P-611.20	-20 to +120 V	115 Hz (in X) 90 Hz (in Y)	3.4 W (in X) 2.6 W (in Y)
P-611.XZS P-611.XZ0	-20 to +120 V	122 Hz (in X) 113 Hz (in Z)	3.6 W (in X) 3.3 W (in Z)
P-611.3S P-611.3SF P-611.3O P-611.3OF	-20 to +120 V	117 Hz (in X) 73 Hz (in Y) 83 Hz (in Z)	3.4 W (in X) 2.1 W (in Y) 2.4 W (in Z)
P-611.ZS P-611.Z0	-20 to +120 V	153 Hz	4.5 W

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the P-611:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa (corresponds to roughly 825 Torr to 0.075 Torr)
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C
Operating temperature	–20 °C to 80 °C
Storage temperature	–20 °C to 80 °C
Transport temperature	–25 °C to 85 °C
Overvoltage category	II
Protection class	I
Degree of pollution	1
Degree of protection according to IEC 60529	IP20

10.2 Dimensions

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

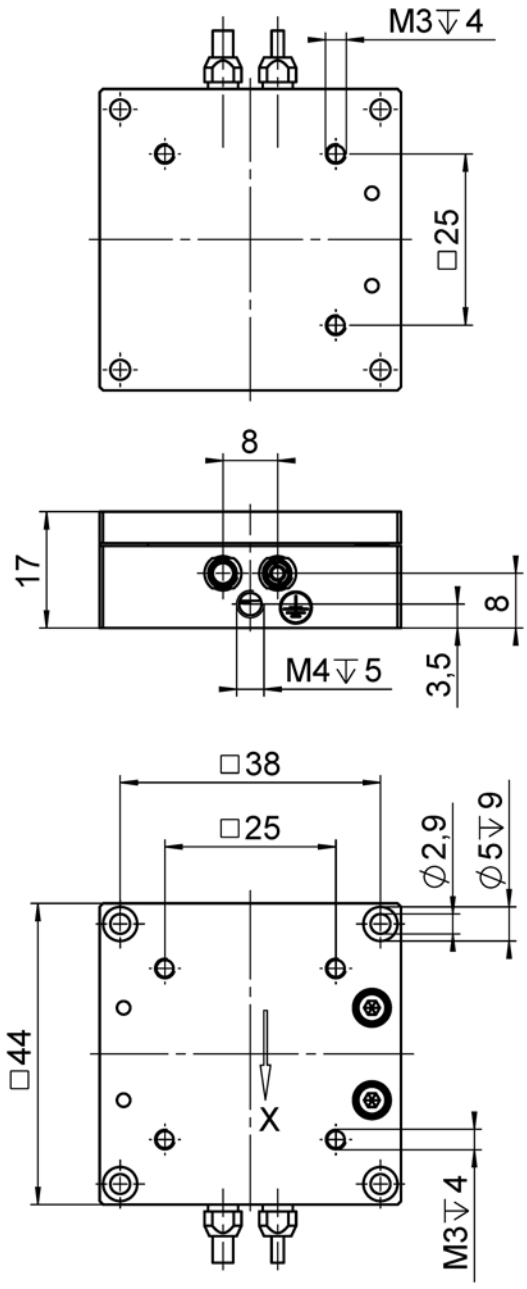


Figure 11: P-611.1S

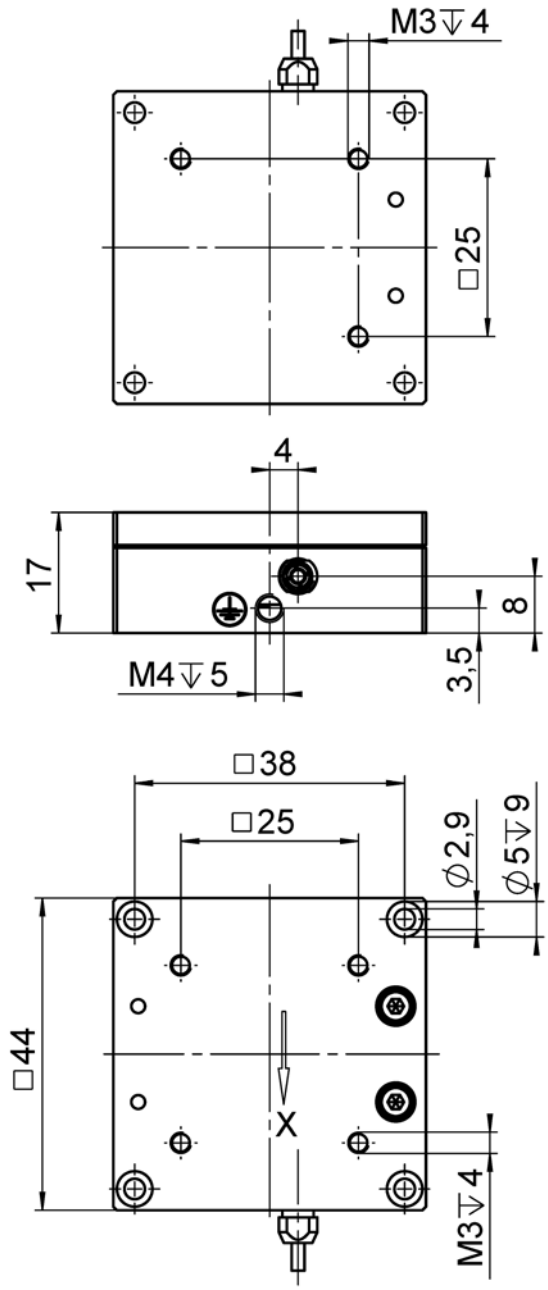


Figure 12: P-611.10

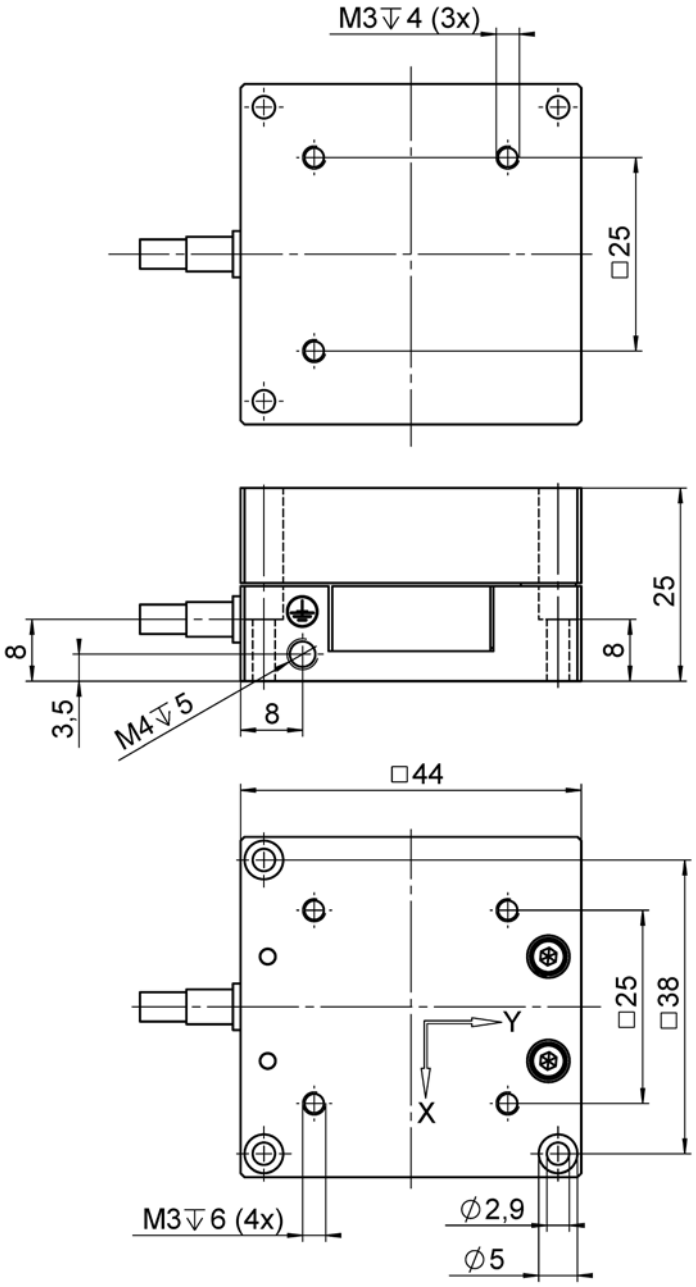


Figure 13: P-611.2S and P-611.20

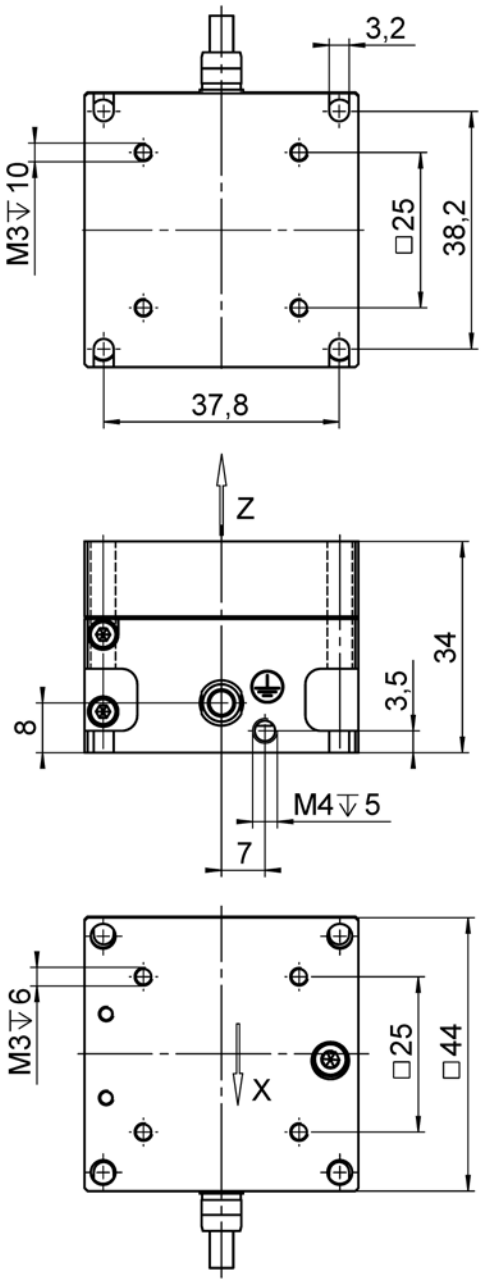


Figure 14: P-611.XZS and P-611.XZ0

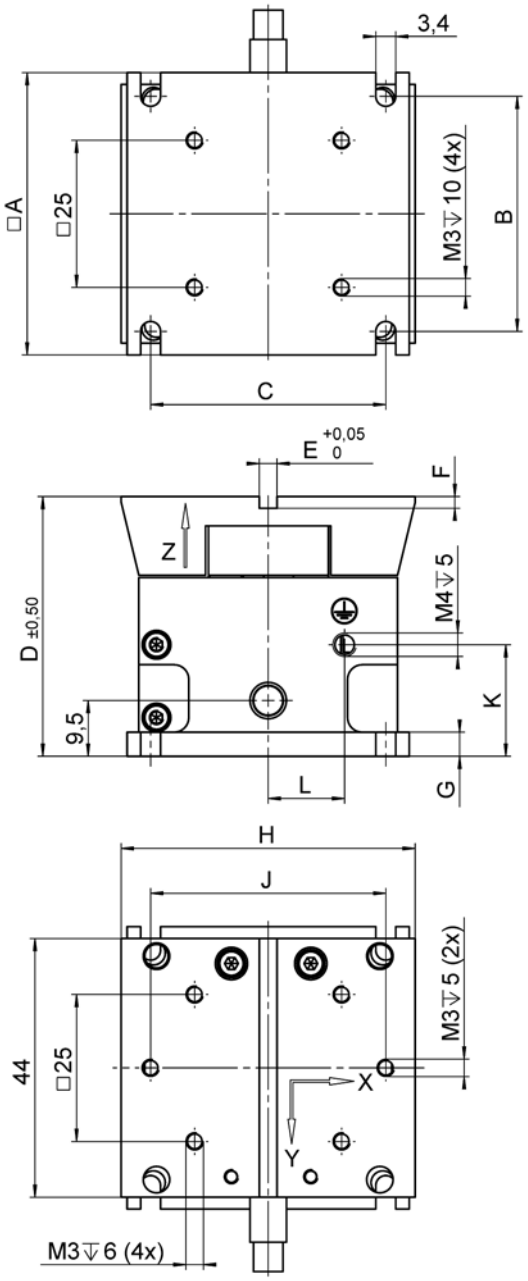


Figure 15: P-611.3O, P-611.3S, P-611.3OF and P-611.3SF

	A	B	C	D	E	F	G	H	J	K	L
P-611.3O	44	38.2	37.8	43.2	-	-	3.5	44	-	3.5	10
P-611.3S	44	38.2	37.8	43.2	-	-	3.5	44	-	3.5	10
P-611.3OF	44	38.2	37.8	44.2	3	2	3.5	50	40	3.5	10
P-611.3SF	48	40	40	44.2	3	2	4.1	50	40	19	13

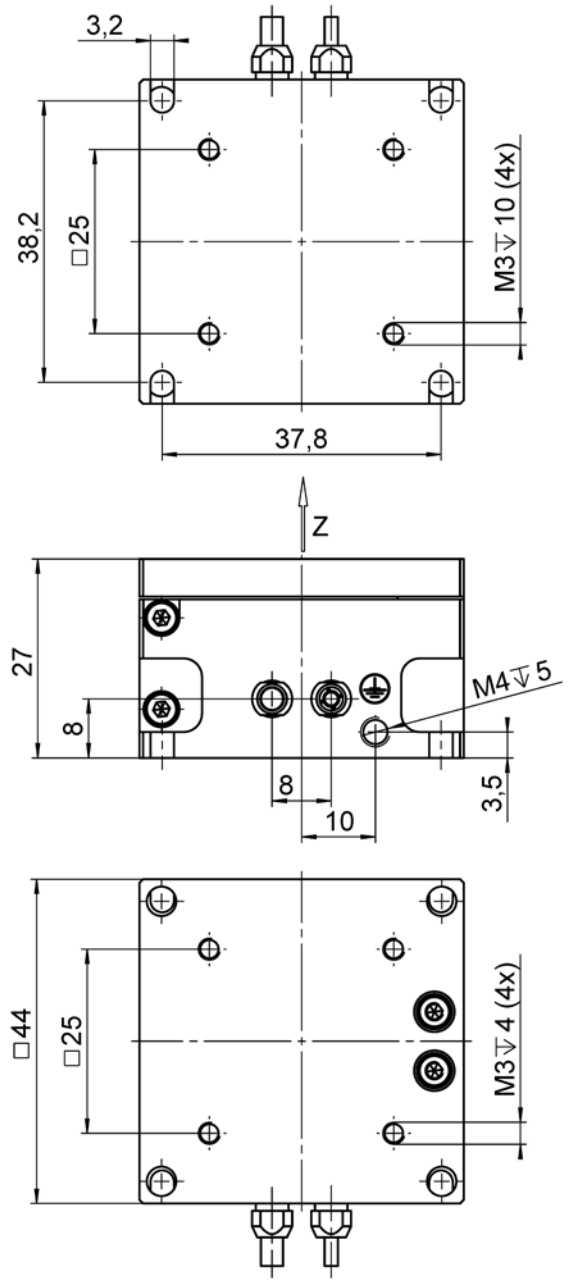


Figure 16: P-611.ZS

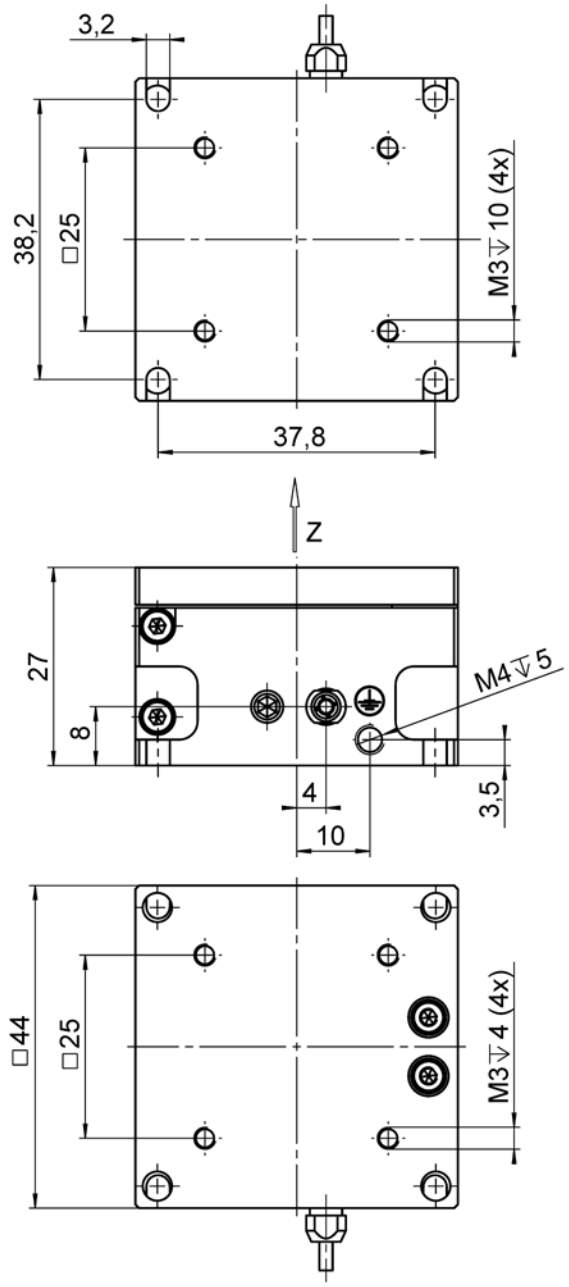


Figure 17: P-611.Z0

10.3 Torque for Stainless Steel Screws (A2-70)

Screw Size	Minimum Torque	Maximum Torque
M6	4 Nm	6 Nm
M5	2.5 Nm	3.5 Nm
M4	1.5 Nm	2.5 Nm
M3	0.8 Nm	1.1 Nm
M2.5	0.3 Nm	0.4 Nm
M2	0.15 Nm	0.2 Nm
M1.6	0.06 Nm	0.12 Nm

10.4 Pin Assignment

Sub-D 25 connector

Only for P-611.3S/.3SF/.3O/.3OF:

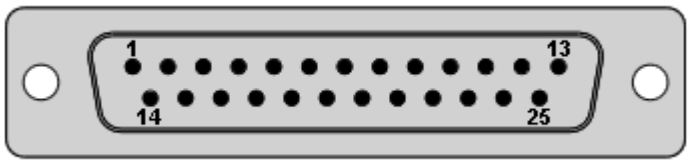


Figure 18: Sub-D 25 connector: Front side with connections

Pin assignment of the Sub-D 25 connector of the P-611.3S/.3SF

Pin	Signal	Function
1	Output	SGS 3-B1 sensor signal
2	Input	SGS 3 reference voltage
3	Output	SGS 2-B1 sensor signal
4	Input	SGS 2 reference voltage
5	Output	SGS 3-B1 sensor signal

Pin	Signal	Function
6	Input	SGS 1 reference voltage
7 to 10	Free	–
11	Input	Piezo voltage +, channel 3
12	Input	Piezo voltage +, channel 2
13	Input	Piezo voltage +, channel 1
14	Output	SGS 3-B2 sensor signal
15	GND	SGS 3 GND
16	Output	SGS 2-B2 sensor signal
17	GND	SGS 2 GND
18	Output	SGS 1-B2 sensor signal
19	GND	SGS 1 GND
20 to 22	Free	–
23	Input	Piezo voltage –, channel 3
24	Input	Piezo voltage –, channel 2
25	Input	Piezo voltage –, channel 1

Pin assignment of the Sub-D 25 connector of the P-611.3O/.3OF

Pin	Signal	Function
1 to 10	Free	–
11	Input	Piezo voltage +, channel 3
12	Input	Piezo voltage +, channel 2
13	Input	Piezo voltage +, channel 1
14 to 22	Free	–
23	Input	Piezo voltage –, channel 3
24	Input	Piezo voltage –, channel 2
25	Input	Piezo voltage –, channel 1

LEMO connectors

Only for P-611.1S/.10/.2S/.20/.XZS/.XZ0/.ZS/.Z0

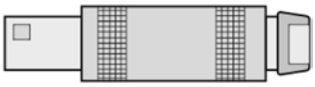


Figure 19: LEMO connector (side view)

LEMO connectors according to model (one connector per axis)

P-611 Model	Connector (Front View)	Pin	Signal	Function	Connector Shell
.1S / .10 .2S / .20 .XZS / .XZ0 .ZS / .Z0	PZT	Inner conductor	Input	Piezo voltage –20 to 120 V	Ground
.1S / .2S / .XZS / .ZS	SGS	1	Input	Supply voltage for strain gauge sensor	Cable shield
		2	Output	Sensor signal 1	
		3	Output	Sensor signal 2	
		4	GND	Ground of the supply voltage	

11 Old Equipment Disposal

In accordance with the applicable EU law, electrical and electronic equipment may not be disposed of with unsorted municipal wastes in the member states of the EU.

When disposing of your old equipment, observe the international, national and local rules and regulations.

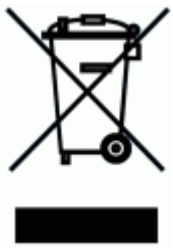
To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG ensures environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

If you have old PI equipment, you can send it postage-free to the following address:

Physik Instrumente (PI) GmbH & Co. KG

Auf der Römerstr. 1

D-76228 Karlsruhe, Germany



12 EC Declaration of Conformity

For the P-611, an EC Declaration of Conformity has been issued in accordance with the following European directives:

2006/95/EC, Low Voltage Directive

2004/108/EC, EMC Directive

2011/65/EU, RoHS Directive

The applied standards certifying the conformity are listed below.

Electromagnetic Emission: EN 61000-6-3:2007, EN 55011:2009

Electromagnetic Immunity: EN 61000-6-1:2007

Safety (Low Voltage Directive): EN 61010-1:2010